

Claims

1. An electronic ballast, comprising:
 - 5 a rectifier circuit adapted to receive a source of alternating current (AC) line voltage, the AC line voltage having a magnitude;
a boost converter coupled to the rectifier circuit and operable to provide a substantially direct current (DC) rail voltage having a steady-state operating level;
 - 10 an inverter coupled to the boost converter;
an output circuit coupled to the inverter and operable to provide power to at least one gas discharge lamp;
 - an inverter startup circuit coupled between the boost converter and the inverter, wherein the inverter startup circuit is operable to provide a delay period
 - 15 between startup of the boost converter and startup of the inverter such that startup of the inverter is delayed until at least such time as the DC rail voltage approaches its steady-state operating level.

2. The ballast of claim 1, wherein the inverter startup circuit is operable to start the inverter only after the DC rail voltage reaches at least ninety percent of its steady-state operating level.

5 3. The ballast of claim 1, wherein the delay period changes in response to a change in the magnitude of the AC line voltage.

4. The ballast of claim 1, wherein the delay period decreases in response to an increase in the magnitude of the AC line voltage.

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5. The ballast of claim 3, wherein:
when the root-mean-square (RMS) magnitude of the AC line voltage is about 120 volts, the delay period is about 27 milliseconds; and

15 when the RMS magnitude of the AC line voltage is about 277 volts, the delay period is about 12.5 milliseconds.

6. The ballast of claim 1, wherein the root-mean-square (RMS) magnitude of the AC line voltage is variable between about 120 volts and about 277 volts.

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7. The ballast of claim 1, wherein the inverter startup circuit comprises:
an input terminal coupled to the boost converter;
first and second output terminals coupled to the inverter;
a first capacitor coupled between the input terminal and a first node;
5 a resistor coupled between the first node and a second node;
a first diode having an anode coupled to circuit ground and a cathode
coupled to the second node;
a second diode having an anode coupled to the second node and a
cathode coupled to a third node;
10 a second capacitor coupled between the third node and circuit ground;
a voltage breakdown device coupled between the third node and the first
output terminal, the voltage breakdown device being operable to conduct current
in response to a predetermined breakdown voltage being provided between the
third node and circuit ground; and
15 a third diode having an anode coupled to the third node and a cathode
coupled to the second output terminal.
8. The ballast of claim 7, wherein the voltage breakdown device is a diac.

9. An electronic ballast, comprising:

a rectifier circuit adapted to receive a source of alternating current (AC) line voltage;

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a boost converter operable to provide a substantially direct current (DC) rail voltage having a steady-state operating level, the boost converter comprising:

first and second input terminals coupled to the rectifier circuit;
10 first and second output terminals, the second output terminal being coupled to second input terminal;

a boost transistor having a first conduction terminal, a second conduction terminal, and a control terminal, wherein the second conduction terminal is coupled to the second input terminal;

15 a boost control circuit coupled to the control terminal of the boost transistor and operable to commutate the boost transistor;

a boost inductor having a primary winding coupled between the first input terminal and the first conduction terminal of the boost transistor;

20 a boost rectifier having an anode and a cathode, wherein the anode is coupled to the first conduction terminal of the boost transistor and the cathode is coupled to the first output terminal; and

a bulk capacitor coupled between the first and second output terminals;

25 an inverter, comprising:

first and second input terminals coupled to the first and second output terminals of the boost converter;

an inverter output terminal coupled to the output circuit;

30 an upper inverter transistor coupled between the first input terminal and the output terminal;

a lower inverter transistor coupled between the output terminal and circuit ground;

a drive circuit for the upper transistor; and
a drive circuit for the lower transistor;

an output circuit coupled to the inverter and operable to provide power to
5 at least one gas discharge lamp;

an inverter startup circuit operable to delay starting the inverter until at
least such time as the boost converter begins to operate and the DC rail voltage
approaches its steady-state operating level, the inverter startup circuit
10 comprising:

an input terminal coupled to the boost converter;
a first output terminal coupled to the drive circuit for the lower
transistor; and
a second output terminal coupled to the inverter output terminal.

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10. The ballast of claim 9, wherein the input terminal of the inverter startup circuit is coupled to the first conduction terminal of the boost transistor.

11. The ballast of claim 9, wherein:

5 the boost inductor further comprises a secondary winding having a first end coupled to the boost control circuit and a second end coupled to the second input terminal of the boost converter; and

the input terminal of the inverter startup circuit is coupled to the first end of the secondary winding of the boost inductor.

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12. The ballast of claim 9, wherein:

the output circuit comprises:

first and second output connections adapted for connection to at least one gas discharge lamp;

5 a resonant capacitor coupled between the inverter output terminal and circuit ground;

an output transformer comprising a primary winding and a secondary winding, wherein:

10 the primary winding has a first end and a second end, the first end being coupled to the inverter output terminal;

the secondary winding has a first end and a second end, the second end being coupled to the second output connection;

a direct current (DC) blocking capacitor coupled between circuit ground and the second end of the primary winding of the output transformer;

15 a ballasting capacitor coupled between the first end of the secondary winding and the first output connection;

the drive circuit for the lower inverter transistor comprises:

20 a base-drive winding that is magnetically coupled to the primary winding of the output transformer, the base-drive winding having a first end and a second end, the second end being coupled to circuit ground;

a base-drive resistor coupled between the first end of the base-drive winding and the lower inverter transistor; and

25 a base-drive diode having an anode and a cathode, wherein the anode is coupled to the lower inverter transistor and the cathode is coupled to the first end of the base-drive winding; and

wherein the first output terminal of the inverter startup circuit is coupled to the anode of the base-drive diode.

13. The ballast of claim 9, wherein the inverter startup circuit further comprises:

- a first capacitor coupled between the input terminal and a first node;
- a resistor coupled between the first node and a second node;
- 5 a first diode having an anode coupled to circuit ground and a cathode coupled to the second node;
- a second diode having an anode coupled to the second node and a cathode coupled to a third node;
- a second capacitor coupled between the third node and circuit ground;
- 10 a voltage breakdown device coupled between the third node and the first output terminal, the voltage breakdown device being operable to conduct current in response to a predetermined breakdown voltage being provided at the third node; and
- a third diode having an anode coupled to the third node and a cathode
- 15 coupled to the second output terminal.

14. The ballast of claim 13, wherein the voltage breakdown device is a diac.

15. The ballast of claim 13, wherein the input terminal of the inverter startup
20 circuit is coupled to the first conduction terminal of the boost transistor.

16. The ballast of claim 13 wherein:
the boost inductor further comprises a secondary winding having a first
end coupled to the boost control circuit and a second end coupled to the second
25 input terminal of the boost converter; and
the input terminal of the inverter startup circuit is coupled to the first end
of the secondary winding of the boost inductor.

17. The ballast of claim 13, wherein:

the output circuit comprises:

first and second output connections adapted for connection to at least one gas discharge lamp;

5 a resonant capacitor coupled between the inverter output terminal and circuit ground;

an output transformer comprising a primary winding and a secondary winding, wherein:

10 the primary winding has a first end and a second end, the first end being coupled to the inverter output terminal;

the secondary winding has a first end and a second end, the second end being coupled to the second output connection;

a direct current (DC) blocking capacitor coupled between circuit ground and the second end of the primary winding of the output transformer;

15 a ballasting capacitor coupled between the first end of the secondary winding and the first output connection;

the drive circuit for the lower inverter transistor comprises:

20 a base-drive winding that is magnetically coupled to the primary winding of the output transformer, the base-drive winding having a first end and a second end, the second end being coupled to circuit ground;

a base-drive resistor coupled between the first end of the base-drive winding and the lower inverter transistor; and

25 a base-drive diode having an anode and a cathode, wherein the anode is coupled to the lower inverter transistor and the cathode is coupled to the first end of the base-drive winding; and

wherein the first output terminal of the inverter startup circuit is coupled to the anode of the base-drive diode.

18. An electronic ballast, comprising:

a rectifier circuit adapted to receive a source of alternating current (AC) line voltage;

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a boost converter, comprising:

first and second input terminals coupled to the rectifier circuit;

first and second output terminals, the second output terminal being coupled to the second input terminal;

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a boost transistor having a first conduction terminal, a second conduction terminal, and a control terminal, wherein the second conduction terminal is coupled to the second input terminal;

a boost control circuit coupled to the control terminal of the boost transistor and operable to commutate the boost transistor;

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a boost inductor having a primary winding coupled between the first input terminal and the first conduction terminal of the boost transistor;

a boost rectifier having an anode and a cathode, wherein the anode is coupled to the first conduction terminal of the boost transistor and the cathode is coupled to the first output terminal; and

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a bulk capacitor coupled between the first and second output terminals;

an inverter, comprising:

first and second input terminals coupled to the first and second output terminals of the boost converter;

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an inverter output terminal coupled to the output circuit;

an upper inverter transistor coupled between the first input terminal and the output terminal;

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a lower inverter transistor coupled between the output terminal and circuit ground;

a drive circuit for commutating the upper and lower inverter transistors in a substantially complementary manner;

an output circuit coupled to the inverter and operable to provide power to at least one gas discharge lamp; and

5 an inverter startup circuit, comprising:

an input terminal coupled to the boost converter;
 a first output terminal coupled to the drive circuit of the inverter;
 a second output terminal coupled to the inverter output terminal;
 a first capacitor coupled between the input terminal and a first

10 node;

a resistor coupled between the first node and a second node;
 a first diode having an anode coupled to circuit ground and a cathode coupled to the second node;

a second diode having an anode coupled to the second node and a cathode coupled to a third node;

15 a second capacitor coupled between the third node and circuit ground;

a diac coupled between the third node and the first output terminal; and

20 a third diode having an anode coupled to the third node and a cathode coupled to the second output terminal.

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19. The ballast of claim 18, wherein the input terminal of the inverter startup circuit is coupled to the first conduction terminal of the boost transistor.

20. The ballast of claim 18, wherein:

5 the boost inductor further comprises a secondary winding having a first end coupled to the boost control circuit and a second end coupled to the second input terminal of the boost converter; and

the input terminal of the inverter startup circuit is coupled to the first end of the secondary winding of the boost inductor.

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